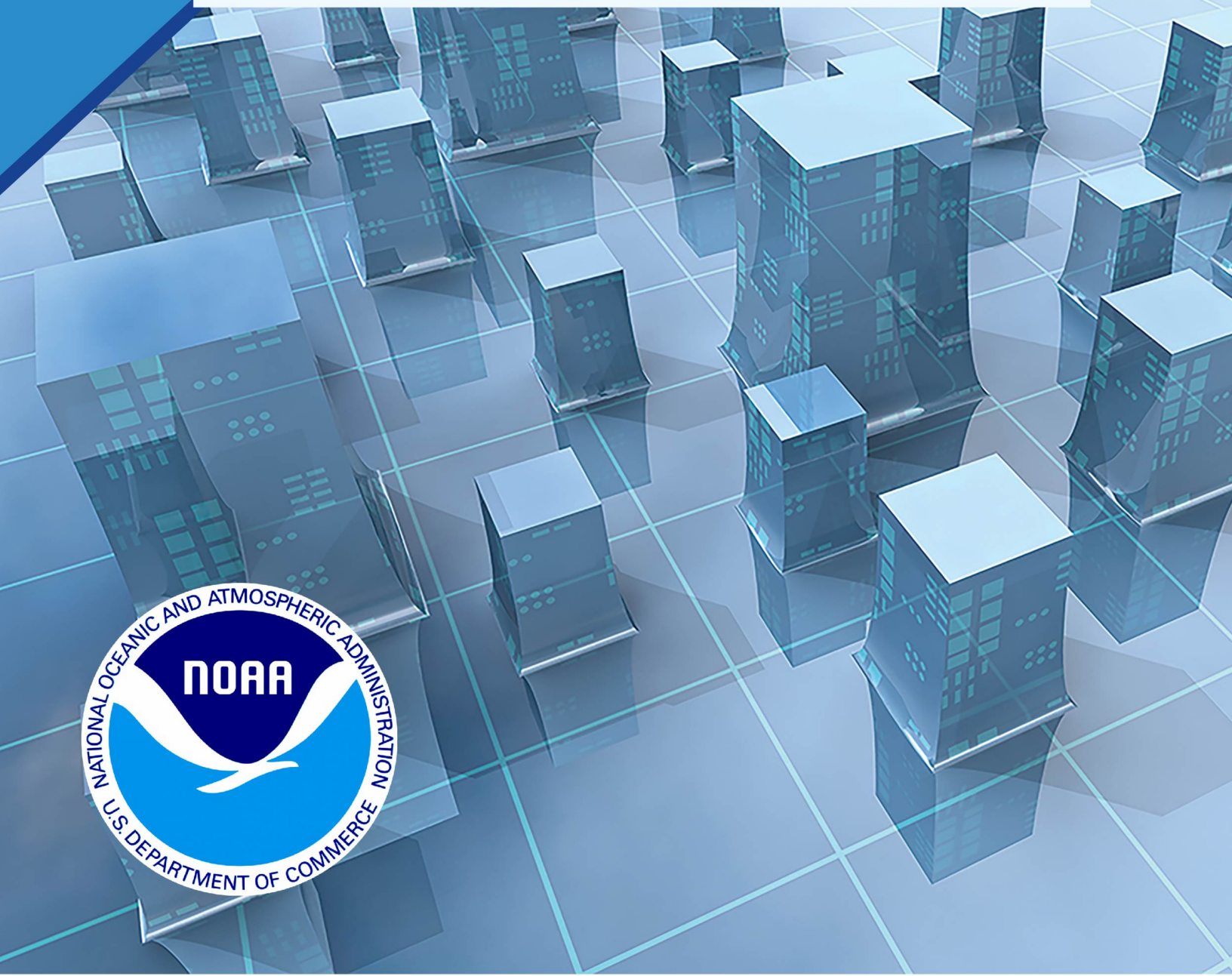
NOAA EMERGING TECHNOLOGIES WORKSHOP

2019 REPORT



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A NOTE FROM THE 2019 WORKSHOP ORGANIZERS

DEAR COLLEAGUES,

As the NOAA Observing Systems Committee (OSC) Co-Chairs hosting the 2019 Emerging Technologies Workshop (ETW), we are proud to highlight the innovation and collaboration made possible with this critical event. First held in 2016, the ETW was launched to identify new technology with the potential to advance NOAA's capabilities to monitor, assess, and predict the environment. Held for the third time in 2019, we are thrilled to report this biennial event has continued to grow and add value to NOAA's observing systems portfolio.

The 2019 ETW took place on June 25-26 at the NOAA Center for Weather and Climate Prediction in College Park, Maryland. The workshop was co-sponsored by NOAA's three strategy councils, the NOAA Observing Systems Council (NOSC), the NOAA Research Council (NRC), and the NOAA Ocean and Coastal Council (NOCC), with input from all NOAA Line Offices. This year's workshop convened nearly 400 in-person and remote attendees for a showcase of Earth observation technology in support of two NOAA priority areas, resilience to extreme weather and water and the Blue Economy.

2019 ETW attendees represented all six NOAA Line Offices as well as stakeholders from other federal agencies and the private sector. Notable presenters included NOAA senior leaders, RDML Timothy Gallaudet, Ph.D., USN Ret. and Dr. Cisco Werner, as well as external representatives from Google, Amazon, the University Corporation for Atmospheric Research, Saildrone, and many others. 2019 ETW presentations featured the greatest number and diversity of external speakers than ever before, due to a more robust campaign to promote the Request for Information (RFI) used to solicit abstracts.

It's also important to note that several new components were launched for this year's workshop. A new session on artificial intelligence was added to the workshop in recognition of the significant potential it has to improve and transform how environmental data can be managed and applied. Additionally, the NOAA Research Council organized the panel discussion focused on the challenges of transitioning research to operations. In addition, the 2019 ETW featured lunchtime tours of NOAA's Science on a Sphere global display and a remote attendee option. With the help of NOAA's Satellite and Information Service communications team, the workshop was also promoted via a social media campaign and attendees were encouraged to share their experience using a dedicated event hashtag.

By reading this report, you'll learn even more about the innovative technologies presented at this year's workshop. The report addresses the overarching themes and takeaways critical to consider for the advancement of NOAA's Earth observation capabilities. Inside you'll find an overview of the key topics covered during both days of the workshop, including summaries on the two keynote speeches, seven workshop sessions, and the leadership panel. The report concludes with key next steps to consider in order to continue growing the ETW and an appendix with supplementary materials of interest. Ultimately, this report aims to inspire your support of and attendance at the next ETW. Finally, we hope you consider collaborating with one of this year's (or future) workshop presenters to harness the potential of their technology to further NOAA's mission.

Sincerely,

THOMAS CUFF — **Director, Office of Observations**
NOAA National Weather Service

RICHARD EDWING — **Director, Center for Operational Oceanographic Products and Services**
NOAA National Ocean Service

2019 REPORT OVERVIEW

2019 REPORT FOCUS AREAS
WHAT IS INCLUDED IN THIS REPORT?

This report is made up of three main sections, highlighting the technologies, insights, and recommendations for consideration captured during the 2019 ETW and through post-workshop feedback activities. This year's workshop was held over the course of two days, with each day focusing on one of two themes, respectively:

- **DAY ONE** focused on NOAA's goal to strengthen national resilience in the face of extreme weather and water events. Sessions focused on exploring technologies offering observation capabilities and infrastructure that can enhance NOAA's understanding of weather variability extreme events, and ecosystem processes.

- **DAY TWO** focused on NOAA's goal to strengthen the U.S. role in the blue economy, the science-based management and sustainable use of ocean resources in support of national, economic, and environmental security (e.g., stimulating economic growth, job creation, quality of life, healthier ocean and coastal ecosystems). Sessions focused on technologies offering data insights with the potential to support NOAA's sustainable development practices to generate economic growth, environmental stability, and preservation.

2019 REPORT TARGET AUDIENCES
WHO SHOULD READ THIS REPORT?

This report is intended for NOAA personnel and external stakeholders who are either already engaged or have an interest in supporting NOAA's Earth observation capabilities. In particular, this report aims to reach the following audience groups:

- **2019 ETW Attendees** interested in reviewing workshop materials and/or collaboration opportunities with a workshop presenter or fellow attendee;

- **2019 ETW Registrants** (or past workshop attendees) unable to attend this year, interested in exploring technologies, insights, and/or presenters featured at the 2019 event;

- **NOAA Senior Leaders and Managers** involved in NOAA observing systems portfolio management interested in learning more about the potential of technologies featured at this year's event; and

- **NOAA Personnel and External Stakeholders** interested in the value of engaging and/or supporting this event in the future as a program planner, workshop sponsor, session speaker, poster presenter, and/or attendee.

2019 REPORT OVERVIEW

2019 REPORT SECTIONS
HOW IS THIS REPORT ORGANIZED?

This report is divided into three main sections to provide: (1) an overview of the materials presented during the 2019 ETW; (2) key insights on workshop successes, challenges, and next steps to grow and sustain this event; and (3) an appendix of supplementary materials relevant to the 2019 ETW.

Section One (pages 4-23) includes detailed summaries on the three different types of sessions presented during the 2019 ETW, including two keynote speeches, seven workshop sessions, and a leadership panel. The first part of this section summarizes sessions that occurred on day one of the workshop, while the second part summarizes sessions that occurred on day two. **Each summary for the seven workshop sessions is organized into two subsections, which include:**

- The name of the session chair and an introduction to the session topic; and
- A summary of the Earth observation technologies presented during the session with details on the presenter's name(s) and organizational affiliation(s), the type of abstract submission, and an explanation of the technology and/or capabilities highlighted in the presentation. Abstracts were submitted in response to two different calls: an internal NOAA call for abstracts and an external Request for Information process.

Section Two (pages 24-26) includes an overview of key insights gathered from workshop attendees and planning staff on the successes, challenges, and lessons learned during this year's ETW. The section closes with next steps (already underway) and additional recommendations (for consideration) to sustain and grow this event as a critical mechanism advancing NOAA's Earth observation capabilities.

Section Three (pages 27-38) is a collection of supplementary documents including the full 2019 workshop agenda, a listing of all posters featured at this year's workshop and an acknowledgments statement.

RDML TIMOTHY GALLAUDET, PH.D., USN RETIRED
Assistant Secretary of Commerce for Oceans and Atmosphere and Deputy NOAA Administrator

DAY ONE: KEYNOTE ADDRESS

To set the stage and identify key expectations for 2019 ETW attendees, the event kicked off with a keynote address from RDML Timothy Gallaudet. In his speech, RDML Gallaudet highlighted the value and relevance of the ETW in context of NOAA's mission and broader goals. He emphasized that this event advances NOAA's ability to succeed in an increasingly data-driven society, where public-private collaboration continues to be critically important.

The Admiral stressed the alignment of key NOAA priorities with technologies presented at this year's ETW that focused on two themes: resilience to extreme weather and water and the Blue Economy. RDML Gallaudet began by describing that while in the past the federal government has funded major innovations, today those advances are often driven in part or completely by private sector funding and technologies. As a result of this shift, he explained that fostering public-private partnerships, a main goal of the ETW, is essential for the United States to continue as a global leader in the science, technology, and innovation realms.

RDML Gallaudet went on to highlight key factors demonstrating the significance and relevance of the 2019 ETW themes. In particular, he referenced the Weather Research and Forecasting Innovation Act of 2017 and its primary aim of furthering the United States as a global leader in weather modeling. He also discussed the rising significance of the Blue Economy, and its aim to maximize the sustainable economic contributions of oceans and coasts. RDML Gallaudet highlighted that NOAA's leadership on the Blue Economy focuses on five pillars: seafood production, ocean exploration, marine transportation, tourism and recreation, and coastal resilience.

The Admiral continued by presenting additional thematic issues that NOAA is addressing in an effort to continue advancing technologically. For example, he described how NOAA is engaging with the private sector to expand space innovation. Additionally, RDML Gallaudet shared four priorities that he is working with NOAA leadership and staff to address: Earth system modeling, 'omics and environmental DNA, artificial intelligence, and unmanned systems. He presented examples of several initiatives and projects within NOAA to support these priorities. In his closing remarks, the Admiral made a compelling and inspiring request to the 2019 ETW attendees, capturing the workshop's ultimate goal. He said, "This week, let's chart a course to the next stunning accomplishments that will ensure our continued American leadership in emerging technologies."

This week, let's chart a course to the next stunning accomplishments that will ensure our continued American leadership in emerging technologies .

DAY ONE - EXTREME WEATHER AND WATER

SESSION ONE
HYDROMETEOROLOGICAL EXTREMES

NEAL DIPASQUALE, SESSION CHAIR
NOAA National Weather Service (NWS)
Evaluation Branch Chief, Surface and Upper Air Division, Office of Observations

Of the various severe weather events, droughts and floods have the greatest socioeconomic impact on both the United States and the global community. The Hydrometeorological Extremes Session explored emerging technologies that offer the potential to enhance NOAA's ability to monitor and predict extreme events.

The technologies featured in this session also offered opportunities to advance scientific understanding and build actionable decision support services at the local, state, tribal, national and international levels. This session's presentations highlighted projects including ready-to-deploy sensors, data packaged for input to existing NOAA servers, and strategies for implementing end users' needs during technology development cycles.

DAY ONE - SESSION ONE
PRESENTATION SUMMARIES

MoPED - Mobile Platform Data Generation for Flash Flooding and Extreme Weather
Paul Heppner, Global Science & Technology (GST)
Submitted via RFI Process

MoPED is a mobile meteorological data acquisition and dissemination system that leverages data from sensors built into commercial delivery vehicles. This system crowdsources real-time, localized, and dynamic environmental situations, including storm cells and patchy severe rain events. MoPED could be used to fill gaps where *in situ* weather stations are not possible or practical to improve flash flood and precipitation predictions and modeling.

Automated NonContact Hydrologic Observations in Rivers
Daniel Wasielewski, NOAA Office of Oceanic and Atmospheric Research (OAR)
Submitted via NOAA Call for Abstracts

Automated Non-Contact Hydrologic Observations in Rivers (ANCHOR) are "smart" radar sensors that directly measure water velocity. This allows for direct calculation of discharge and lengthens the prediction window of flash flood warnings. ANCHOR sensors are intended to complement existing observational systems, such as U.S. Geological Survey's streamgages. Additionally, this system informs hydrologic models used by NOAA by providing temporary coverage to inform and calibrate models. ANCHOR can also be placed in streams that are too small, too risky, or too inaccessible for conventional gages to be economically viable.

DAY ONE - EXTREME WEATHER AND WATER

SESSION ONE
HYDROMETEOROLOGICAL EXTREMES

DAY ONE, SESSION ONE
PRESENTATION SUMMARIES (cont'd)

FFIoT – Flash Flood Internet-of-Things
Chris Ulmer, Intellisense Systems Inc. (ISI)
Submitted via RFI Process

The Real-Time Flash Flood and Reporting (RAFFAR) sensor paired with a developing Flash Flood Internet-of-Things (FFIoT) system provides flash flood detection and stream rate-of-flow measurements in areas with inadequate water gauge coverage. RAFFAR can be rapidly deployed prior to flash flood events using less physical infrastructure. As a result, this capability enables higher resolution flood models and faster, more accurate planning and response to flash floods.

Decision Support at Regional Scales: Connecting Emerging Technologies to User Needs in a NOAA Services Framework
Ellen Mecray, NOAA National Environmental Satellite, Data, and Information Service (NESDIS)
Submitted via NOAA Call for Abstracts

The NOAA Services Framework describes the role that NOAA service delivery agents from across NOAA Line Offices play in the agency's process for start-to-end user engagement. Service delivery agents work with NOAA customers to better understand and respond to their needs and also ensure that customers are able to access and understand NOAA information. The agents rely on the tools and techniques developed by NOAA Line Offices to improve the application of decision support services and enhance NOAA's mission.

SESSION TWO
REMOTE SENSING FOR EXTREME ATMOSPHERIC EVENTS

JOHN CORTINAS, PH.D., SESSION CHAIR
NOAA Office of Oceanic and Atmospheric Research (OAR)
Director, Office of Weather and Air Quality

Understanding storm systems is becoming more important as climate changes fuel increasing storm frequency, severity, and human impacts. Rapid impact assessment of storm damage and intensity is vital to informing community response and recovery. Available storm intensity information is often limited, slowing response and recovery. In this session, five presentations addressed a variety of technologies created to optimize observing severe weather events.

Presentation topics ranged from tools aboard storm flight missions to low-orbit unmanned aerial vehicles. Combined with the appropriate software and the capacity to relay information in real time, these technologies offer significant potential to improve the forecasting of developing storms.

DAY ONE - EXTREME WEATHER AND WATER

SESSION TWO
REMOTE SENSING FOR EXTREME ATMOSPHERIC EVENTS

DAY ONE, SESSION TWO
PRESENTATION SUMMARIES

Wide Swath Radar Altimeter
Edward Walsh, NOAA Office of Oceanic and Atmospheric Research (OAR)
Submitted via NOAA Call for Abstracts

The Wide Swath Radar Altimeter (WSRA) is an aircraft mounted phased-array antenna that measures ocean surface wave information, rain rate, and storm surge during hurricanes. By employing a low-frequency radar, the WSRA performs especially well in heavy rainfall and does not require absolute intensity calibration of the system. The WSRA antenna could be incorporated into existing NOAA WP-3 aircraft and storm flight plans. As a result, this would provide real-time, accurate, and detailed information on wave and rain rate information, including storm surge along coasts.

Airborne Phased Array Radar (APAR)
Dr. Vanda Grubišić, UCAR
Submitted via NOAA Call for Abstracts

The Airborne Phased Array Radar (APAR) is an airborne dual-polarization Doppler radar equipped with processing, control and display software deployed on C-130 aircraft during high impact weather events. The APAR can measure microphysical cloud properties, describe three-dimensional wind fields in near real-time, and complement existing fixed radar networks. By improving how high-impact weather events are understood, the APAR could inform new forecasting techniques and improve weather prediction models.

Stratospheric Observations of Earth Systems (SOES)
Kenneth Howard, NOAA Office of Oceanic and Atmospheric Research (OAR)
Submitted via NOAA Call for Abstracts

The Stratospheric Observations of Earth Systems (SOES) is comprised of a fleet of unmanned vehicles deployed in the stratosphere. The Stratollites offer capabilities to host reconfigurable sensor packages for near real-time observations. Each Stratollite is built for prolonged, low-cost missions surveilling areas of interest to inform forecasts and warnings of high-impact events. The SOES is capable of observing weather events in areas with inadequate Next Generation Weather Radar (NEXRAD) coverage.

Airborne Doppler Wind Lidar Sounder
George Emmitt, Simpson Weather Associates (SWA)
Submitted via NOAA Call for Abstracts

The Airborne Doppler Wind Lidar (DWL) Sounder is a scanning lidar, which is capable of a variety of scan patterns for collecting real-time wind profiles during hurricanes and other severe storms. DWL Sounders are built to complement radars and augment wind soundings provided by dropsondes. The use of DWL Sounders also has the potential to increase the vertical and horizontal coverage of directly measured winds. Additional benefits of DWL Sounders are currently being explored, and include providing aerosol information and wind soundings in the presence of rain.

DAY ONE - EXTREME WEATHER AND WATER

SESSION TWO
REMOTE SENSING FOR EXTREME ATMOSPHERIC EVENTS

DAY ONE, SESSION TWO
PRESENTATION SUMMARIES (cont'd)

The Airborne Radar Network (AirNet) Project
Jonathan Gourley, NOAA Office of Oceanic and Atmospheric Research (OAR)
Submitted via NOAA Call for Abstracts

The Airborne Radar Network (AiRNet) project aims to access the data generated from X-band radars, already present on most corporate and commercial jets, and transmit the data to the ground in real time. This capability was developed to complement existing radar networks. It provides coverage in areas with known gaps, primarily in the mountainous western United States and the open ocean. As a result, this project is positioned to improve data synthesis, monitoring, and prediction of severe weather.

SESSION THREE
ARTIFICIAL INTELLIGENCE

SIDNEY THURSTON, PH.D., SESSION CHAIR
NOAA Office of Oceanic and Atmospheric Research (OAR)
Overseas Program Development, Global Ocean Monitoring and Observing

Artificial intelligence is spreading across numerous industries in various applications. At the AFCEA Washington DC Artificial Intelligence and Machine Learning Tech Summit on March 27, 2019, Federal CIO Suzette Kent highlighted the various applications of artificial intelligence to the federal government, noting "the transformative capabilities we're talking about now help us solve some of our most complex problems faster and in ways that we couldn't even imagine many years ago." [1] NOAA has recently used artificial intelligence to support a variety of initiatives, including:

- Accurately predicting Hurricanes Michael and Florence, saving countless lives;
- Assisting U.S. fisheries in recovering 45 fish species, yielding $212B in economic activity;
- Mapping U.S. seaports to ensure more efficient operations, delivering $4.6T in economic activity.

This session included six presentations that addressed topics ranging from the use of cloud storage and processing to the applications of artificial intelligence to enhance the development of NOAA data products. These tools and techniques demonstrated how the public and private sectors are working to revolutionize current methodologies for generating actionable intelligence from the vast amount of available environmental observations.

[1] AI Game-Changers in Federal IT. (05/03/2019).
https://www.governmentciomedia.com/ai-game-changers-federal-it

DAY ONE - EXTREME WEATHER AND WATER

SESSION THREE
ARTIFICIAL INTELLIGENCE

DAY ONE, SESSION THREE
PRESENTATION SUMMARIES

Amazon Web Services
Joseph Flasher, Amazon Web Services (AWS)
Submitted via NOA Call for Abstracts

Amazon Web Services (AWS) offers data storage in the cloud, as well as on-demand computing resources for sharing and analyzing large volumes of data on a global level. Custom applications can be developed by connecting AWS's wide range of technology options with tailored functionality developed by individual customers. Making NOAA's environmental data holdings available to the public via AWS will reduce latency time. In addition, by leveraging this technology, NOAA can broaden public access to its data and the associated tools needed for data collection, analysis, etc.

Google Cloud's Efforts to Enhance Data Discoverability and Access
Shane Glass, Google Cloud
Submitted via NOAA Call for Abstracts

Google Cloud has several tools that improve data discovery and access to geospatial and remote sensing datasets. These include Google Dataset Search, Google Cloud Public Datasets Program, and Google Earth Engine. Additionally, Google Cloud offers access to machine learning and artificial intelligence tools that help users analyze and visualize these datasets more quickly. These capabilities streamline existing workflows that require access to large volumes of data. Furthermore, these tools allow scientists to share their analysis more immediately, make their data available to other users, and support reproducibility of their work.

Machine Learning for Earth Observations and Environmental Prediction
Jebb Stewart (for Sid Boukabara), NOAA National Environmental Satellite, Data and Information Service (NESDIS)/Center for Satellite Applications and Research (STAR)
Submitted via NOAA Call for Abstracts

This presentation highlighted the use of machine learning to help enhance the process of creating environmental data products from satellite imagery. Artificial intelligence has the potential to improve the timeliness, accuracy, and quality at specific steps of the process. For example, the NOAA Center for Satellite Applications and Research is piloting a next-generation enterprise remote-sensing algorithm that integrates artificial intelligence techniques. Incorporating machine learning could provide several benefits to NOAA's Earth observation and environmental prediction work, including (1) increased cost efficiency, (2) modern, maintainable alternatives to legacy algorithms, and (3) enhancements of existing tools.

DAY ONE - EXTREME WEATHER AND WATER

SESSION THREE
ARTIFICIAL INTELLIGENCE

DAY ONE, SESSION THREE
PRESENTATION SUMMARIES (cont'd)

The Weather Archive and Visualization Environment (WAVE
Jebb Stewart, NOAA Office of Oceanic and Atmospheric Research (OAR)/Earth System Research Laboratory (ESRL)
Submitted via NOAA Call for Abstracts

Weather Archive and Visualization Environment (WAVE) is a web-based model, observation viewer and archive that runs entirely on a cloud platform. This software generates forecast and model images and animations. WAVE allows forecasters to share results at emergency operations centers, wildfire sites, forecast offices, and on social media platforms. By adopting WAVE, NOAA forecasters could produce forecasts and warnings in a timely fashion from any location with Internet access. In addition, the capability could improve NOAA's ability to communicate and coordinate with emergency management agencies and other external partners.

A Data Driven Approach for Modeling Ocean Temperature and Salinity Using Observational and Computational Data
Luca Bonfiglio, MIT Sea Grant
Submitted via NOAA Call for Abstracts

This project addresses computational and financial constraints of existing ocean prediction models. The capability uses machine learning to build on and assimilate these existing models and datasets. Machine learning techniques often rely on datasets that are expensive and time-consuming to assemble. This technology attempts to remove that bottleneck by ingesting and fusing multiple pre-existing, disparate data sources. The project uses a Gaussian process regression model to assimilate environmental data from sources of varying fidelities (e.g., deep-water sensors, buoys, or satellites and computational models) to build a complex, data-driven ocean prediction model.

Deep learning approach for detecting precursors of tropical cyclones - Toward Cyclogenesis Prediction
Daisuke Matsuoka, JAMSTEC
Submitted via NOAA Call for Abstracts

This presentation highlighted JAMSTEC's use of artificial intelligence and deep learning approaches in conjunction with cloud-resolving simulation data to better detect the precursors of tropical cyclones. These techniques have a probability of detecting the birth of tropical cyclones in approximately 80% of cases in the study area. Adding this technology to the existing tools offers opportunities to improve NOAA's ability to produce operational tropical cyclone forecasts and warnings.

DAY ONE - EXTREME WEATHER AND WATER

SESSION FOUR
DATA ANALYTICS, PART ONE

KIM VALENTINE, SESSION CHAIR
NOAA National Ocean Service (NOS)
Geospatial Data Manager, Office of the Assistant Chief Information Officer (ACIO)

NOAA is a science-based, data driven organization and has continued to benefit as access to high-resolution data has increased exponentially. This benefit brings with it a growing challenge, however. Scientists struggle to fully exploit these data within the time interval available to inform management decisions. In an effort to address this barrier, the Data Analytics Session highlighted five proposed capabilities.

The presentations addressed modernizing the approach to serving NOAA's satellite imagery and data visualization. The session also included insights on real-time data mining capabilities for processing social media streams. Additionally, it showcased a new platform that provides insight into program financials through data federation and visualization.

DAY ONE, SESSION FOUR
PRESENTATION SUMMARIES

Geospatial Image Services for NOAA's Geostationary Weather Satellite Constellation
Rafael de Ameller, NOAA National Environmental Satellite, Data, and Information Service (NESDIS)
Submitted via NOAA Call for Abstracts

NOAA Satellite Maps is a geospatial data map service that enables its users to access imagery from NOAA's geostationary satellites. NOAA satellite data is made available as both map services and GIS layers. The technology allows a variety of users to easily combine GOES-16 and GOES-17 satellite imagery with georeferenced data layers from other datasets. As a result, the capability enables users to create custom analyses and data visualizations. Ultimately, this improves the types of analyses that specialists can include in web maps for their stakeholders

Real-time Event Identification in Social Sources (REISS)
John Chauvin, Intellisense Systems Inc. (ISI)
Submitted via RFI Process

Real-time Event Identification in Social Sources (REISS) uses a deep learning analytics engine to process large volumes of social media data in real-time. By leveraging this approach, the REISS identifies user-defined events and phenomena as well as verifies warnings. The analyses evolve with incoming information, so the reports are updated as situations unfold, while also filtering out false alarms. This system uses data mining and exploitation techniques to help automate this process, reducing labor costs and the need for human monitors. REISS offers the potential for NOAA to improve its support of emergency management activities across the U.S. Specifically, NOAA could advance the ability of emergency managers to verify warnings and improve its response activities.

DAY ONE - EXTREME WEATHER AND WATER

SESSION FOUR
DATA ANALYTICS, PART ONE

DAY ONE, SESSION FOUR
PRESENTATION SUMMARIES (cont'd)

Live Access Server data visualization and analysis platform (LAS)
Eugene Burger, NOAA Office of Oceanic and Atmospheric Research (OAR)
Submitted via NOAA Call for Abstracts

The Live Access Server (LAS) is a web-based data visualization and analysis platform. This platform provides an extensible and configurable framework to visualize gridded geospatial datasets. The LAS serves data from a variety of sources, including third-party data servers, especially NOAA's Environmental Research Division's Data Access Program (ERDDAP). This platform is currently available for use at no cost to NOAA and to the wider geospatial data community. The LAS offers NOAA the capability to render scientific, publication-ready, and fully documented visualizations not commonly offered by off-the-shelf tools.

Hyperspectral Imager for Updated Littoral Situational Awareness (HULA)
Charles Bachmann and Reid Nichols, RIT/Chester F. Carlson Center for Imaging Science
Submitted via RFI Process

Hyperspectral Imager for Updated Littoral Situational Awareness (HULA) is an integrated system for monitoring and mapping near-shore environments, using a combination of databases, *in situ* and remote sensors, and physical models. This technology collects data from two separate platforms: a ground-based hyperspectral sensor, and an unmanned airborne system with a multi-sensor payload. The imagery can be analyzed to extract important coastal features for remote sensing and mapping. This HULA image data can be used to provide updated nearshore information that can support weather forecasts and ocean observing platforms. As a result, HULA could support NOAA in providing updated maritime domain awareness to help protect life and property.

NESDIS Financial Management Data System (FMDS)
Michael Weiland, NOAA National Environmental Satellite, Data, and Information Service (NESDIS)
Submitted via NOAA Call for Abstracts

The NESDIS Financial Management Data Systems (FMDS) is a cloud-based tool that uses advanced predictive models. These models are built to provide actionable intelligence on program and contract costing behaviors to financial decision makers. The NESDIS FMDS, which runs in an Amazon Web Services environment, delivers an enterprise view of financial data across the 20 NESDIS Programs with separate NESDIS and NASA views of financial performance. This system provides a reliable, scalable, and secure cloud computing environment. Leveraging this technology helps NESDIS eliminate the burden of complex and costly hardware, network and software installation, configuration, and maintenance.

DR. FRANCISCO WERNER, PH.D.
NOAA National Marine Fisheries Service (NMFS) Director of Scientific Programs and Chief Science Advisor

DAY TWO: KEYNOTE ADDRESS

To introduce the workshop's second day, attendees heard from Dr. Francisco Werner, who provided greater insight into the day's Blue Economy theme and its critical relevance to NOAA's mission. He began by defining the Blue Economy as encompassing "the resources and services the ocean provides that in turn drive the U.S. economy, including fisheries, aquaculture, transportation, and tourism."

> ***The Blue Economy [is] the resources and services the ocean provides that in turn drive the U.S. economy-including fisheries, aquaculture, transportation, and tourism.***

Dr. Werner went on to highlight that the overarching themes and technologies being showcased at the 2019 ETW are at the core of advancing NOAA's priorities associated with the Blue Economy. Specifically, he indicated that NOAA is working to strengthen public-private partnerships, promote the use of transformative technologies, and accelerate the transition from research to operations.

Throughout his address, Dr. Werner highlighted several examples of transformative technologies, such as unmanned systems and genomics, to be presented later in the day. More specifically, he used the example of stock assessments to highlight how new technologies are being used to advance traditional survey methods. For example, he referenced unmanned vehicles like SAILDRONE that contain a suite of oceanic and atmospheric sensors and enable scaling down current duties conducted by research vessels. Dr. Werner also discussed how NOAA is using eDNA to inform biological data collection on fish species. In particular, he pinpointed the combined capabilities offered by using eDNA in conjunction with unmanned vehicle observations and acoustic trawl surveys. Together, these capabilities enable improved stock assessments and inform optimized marine resource management.

Dr. Werner continued by sharing key factors for attendees to consider regarding the challenges of transitioning new technologies from research and/or development stages to operations. He emphasized barriers associated with the cost of investment and development; the process of data calibration; and the adoption of models to incorporate new data streams. He concluded by reiterating that in order for NOAA to move forward, fostering private and academic collaborations must continue to be a priority. Dr. Werner emphasized that such partnerships offer the greatest potential for improved data usage, enhanced modeling practices, and ultimately better transitions from research to operations.

DAY TWO - THE BLUE ECONOMY

SESSION FIVE
RESOURCE MAPPING

FRANKLIN B. SCHWING, PH.D., SESSION CHAIR
NOAA National Marine Fisheries Service (NMFS)
Director of Science Information, Office of Science and Technology

According to the NOAA Business Brief, "to advance America's economic, security, and environmental interests, it is critical [to] explore, map, and inventory [the] nation's waters and understand their role in and the effects of a changing climate."[2] Critical to this goal are the observing systems that characterize ocean ecosystems and provide essential information to support the management of ocean and coastal resources.

This session showcased several emerging technologies that support such observing systems, including technologies that conduct observations in support of fisheries management. As seafood production is a key component of the Blue Economy, capabilities presented in this session for conducting habitat assessments, monitoring fishing vessels, and conducting fish surveys all addressed important observing needs.

Topics highlighted in the session included the value of public-private partnerships, the use of individual technologies for multiple applications, and the use of cost-effective technologies to support marine ecosystem characterization.

[2] NOAA Business Brief.
https://www.noaa.gov/sites/default/files/atoms/files/BusinessBrief-online_0.pdf

DAY TWO, SESSION FIVE
PRESENTATION SUMMARIES

Fish-i
Erik C. Franklin, University of Hawai'i - Hawaii Institute of Marine Biology
Prospero Naval, University of the Philippines
Submitted via RFI Process

Fish-i consists of a camera array and a machine learning system that analyzes image data from underwater video footage. Data gathered from the footage can be used to estimate fish biomass, determine fish count, and identify fish species. The Fish-i camera system can be deployed autonomously from remotely operated vehicles, ships, or coastal locations. Fish-i software can also be used to analyze existing unprocessed videos and help avoid video backlogs. In addition, the species identification software component could minimize labor costs by reducing the need for specialized taxonomists. Fish-i also offers the potential for stakeholders with limited funding to engage the support of citizen scientists in monitoring activities. Fish-i could complement existing NOAA fisheries data collection methods to support marine resource management activities.

DAY TWO - THE BLUE ECONOMY

SESSION FIVE
RESOURCE MAPPING

DAY TWO, SESSION FIVE
PRESENTATION SUMMARIES (cont'd)

Underwater Spherical Camera System
Ryan Caillouet, NOAA National Marine Fisheries Service (NMFS)
Submitted via NOAA Call for Abstracts

The Underwater Spherical Camera System (SphereCam) is a camera array that produces near-spherical coverage and can be deployed in a variety of configurations. The SphereCam improves on existing cameras used in fish surveys and habitat monitoring by providing high-precision images with low distortion at a lower cost. The SphereCam's 360 field of view offers an improved alternative to existing cameras with an increased precision of fish and habitat monitoring. The NOAA Southeast Fisheries Science Center has already replaced restricted field-of-view cameras with the SphereCam in different fish and habitat monitoring efforts.

SAILDRONE: A Global USV Network for In-Situ Ocean Observations
Nora Cohen, SAILDRONE, Inc.
Submitted via RFI Process

SAILDRONE is a physical unmanned surface vehicle (USV), software, and data dissemination package that operates on a "data-by-service" basis. SAILDRONE can measure a suite of atmospheric, surface, and sub-surface parameters. The drone can be re-programmed underway to follow a path or remain static. In addition, SAILDRONE can be deployed up to 12 months at a time and has the ability to relay information to satellites in real time. SAILDRONE is meant to fill gaps not covered by other surface observation technologies and is already in use by NOAA to address a range of observing needs.

VMS Augmented with Satellite and Terrestrial AIS and The Newly Available Hawkeye360 Data
Steve Lewis, NOAA National Marine Fisheries Service (NMFS)
Submitted via NOAA Call for Abstracts

This presentation highlighted the integration of Automatic Information System (AIS) data with vessel monitoring system (VMS) data. This capability uses the last known location determined by onboard AIS and VMS technology combined with Hawkeye360 satellite data to track vessels. AIS and VMS can be turned off, resulting in ships going dark, which is a key issue in vessel monitoring. Hawkeye360 satellite data provides information that can address this gap by tracking vessels that go dark. These technologies offer opportunities to improve the monitoring of illegal, unreported, and unregulated fishing.

DAY TWO - THE BLUE ECONOMY

SESSION FIVE
RESOURCE MAPPING

DAY TWO, SESSION FIVE
PRESENTATION SUMMARIES (cont'd)

Fathom Live Aquatic EcoSystem Observer
Jeremy Kuehner and Aaron Legge, InnovaSea Systems
Submitted via RFI Process

The Fathom Live Aquatic Eco System Observer consists of acoustic telemetry tags, semipermanent water sensors, a surface hub, cloud-centric database, and software for data analysis. Data from the sensors is transmitted wirelessly to the surface hub and then to the cloud-based database. The data can then be analyzed by applications accessible from a variety of devices. Fathom Live could be deployed as an end-to-end observing suite to support NOAA's observing needs on the interaction of marine animals with their environments in real time.

SESSION SIX
COASTAL RISK

JONATHAN PENNOCK, PH.D., SESSION CHAIR
NOAA Office of Oceanic and Atmospheric Research (OAR)
Director, National Sea Grant College Program

NOAA's vision for the future includes healthy ecosystems, communities, and economies that are resilient in the face of change. Timely, usable information plays a key role in this endeavor. This session explored how new technologies and techniques can be applied to mitigating risk to coastal communities and ecosystems. Monitoring coastal water quality is essential for protecting human health. More specifically, it is essential in a variety of areas, including monitoring water quality for shellfish aquaculture and determining recreational swimming conditions. The technologies presented in this session help address some of the challenges of observing and monitoring coastal ecosystems. Five presentations described a variety of approaches, including flexible sensor-agnostic platforms, easily deployable low-cost sensors, and increased opportunities for citizen science.

DAY TWO, SESSION SIX
PRESENTATION SUMMARIES

Smartcoastlines.org - Realization of Scalable, Low-cost, Versatile, Environmental Internet of Things for the Coastal Zone
Brian T. Glazer, University of Hawai 'i at Manoa
Submitted via RFI Process

Smartcoastlines.org is a web portal that houses and analyzes data gathered from small and relatively inexpensive Internet of Things sensors called miniNodes. They include temperature, wind, dissolved oxygen, and custom water level sensors. Due to their low cost, miniNodes are ideal for deployment in areas where sensors are at higher risk for environmental damage (e.g., wave break zones). This low-cost capability is more accessible to those with smaller budgets, including students, local non-profits, and citizen scientists.

DAY TWO - THE BLUE ECONOMY

SESSION SIX
COASTAL RISK

DAY TWO, SESSION SIX
PRESENTATION SUMMARIES (cont'd)

Containerized Autonomous Marine Environment Laboratory (CAMEL)
Andrew Ziegweid, ASV Global
Submitted via RFI Process

The Containerized Autonomous Marine Environment Laboratory (CAMEL) is a portable lab with sensors, a support system for command and control, and capabilities for data processing. CAMEL includes an unmanned surface vehicle and an unmanned underwater vehicle, which contain a range of sensors. This system has the capacity to operate in post-disaster areas and expands the capacity for rapid impact assessments of storm damage and intensity, including impacts to ports. In addition, CAMEL can be used for research on fluid mechanics and turbulence, sea-level rise, coastal sustainability, and resilience. The system can also be deployed with minimal infrastructure and used for shallow water surveys.

Advanced Coastal Monitor: Autonomy and Modularity in Marine Survey Vehicles
William Latham, Tridentis AMV
Submitted via NOAA Call for Abstracts

The Advanced Coastal Monitor (ACM), an autonomous surface vehicle (ASV), and the Bottom Feeder, an autonomous underwater vehicle (AUV), can support a range of coastal and ocean observations. The ACM offers a variety of cost saving benefits and can support a wide range of coastal observing needs. The Bottom Feeder, which also has the option to be tethered, is specifically built to operate in the mesophotic zone. As a result, this AUV is highly maneuverable and can avoid collisions in sensitive habitats, such as coral reefs. Both vehicles can improve on current technologies by offering a customizable suite of sensors to help fulfill NOAA's observing needs.

Mobile, In-situ HAB Toxin Warning and Genomic Observation for the Great Lakes
Greg Doucette, NOAA National Ocean Service (NOS)
Submitted via NOAA Call for Abstracts

This presentation showcased a new generation of long-range autonomous underwater vehicles (AUV) that can be deployed in harmful algal blooms as they develop. These AUVs, which offer cost-saving opportunities, measure near real-time conditions of the bloom and relay data back to on-shore data managers. The technology can also archive samples that can be used for DNA barcoding and 'omics studies once the AUV is recovered post-mission. These vehicles can provide near real-time data on algal blooms and toxin levels, which are crucial for managers dealing with the increasing prevalence of harmful algal blooms. The data that these AUVs collect can help inform warnings and forecasts, as well as shellfish and drinking water management decisions.

DAY TWO - THE BLUE ECONOMY

SESSION SIX
COASTAL RISK

DAY TWO, SESSION SIX
PRESENTATION SUMMARIES (cont'd)

HABscope: A Tool for Use by Citizen Scientists to Facilitate Near Real-Time Warning of Respiratory Irritation Caused by Toxic Blooms of *Karenia brevis*
Chris Holland, NOAA National Ocean Service (NOS)
Submitted via NOAA Call for Abstracts

HABscope is a tool that can be used by citizen scientists to monitor *Karenia brevis*, a species responsible for harmful algal blooms that produce toxic aerosols. In order to harness this technology, a number of components are important to consider. First, citizen scientists record videos of water samples using a microscope and phone app and upload the information to a database. Second, the data is analyzed using a program that recognizes and counts *K. brevis* cells. The cell count data is then combined with wind speed and direction data to generate real-time predictions for the next 24 hours. As the blooms can be patchy, the predictions warn vulnerable populations to avoid beaches only when a significant risk is likely. These warnings can reduce health risks and help minimize economic losses to beachside communities.

SESSION SEVEN
DATA ANALYTICS, PART TWO

DAY TWO, SESSION SEVEN
PRESENTATION SUMMARIES

JOHN MCDONOUGH, PH.D., SESSION CHAIR
NOAA Office of Marine and Aviation Operations (OMAO)
Acting Chief, Planning & Performance Management Division

NOAA supports the Blue Economy through the acquisition, processing, and application of reliable data and data products. These are used to support decisions related to managing natural resources, as well as discovering new resources and stimulating new economic activities. Access to high resolution data in support of the Blue Economy is increasing exponentially, but the ability of scientists to fully exploit these data within the time interval available to inform management decisions is a growing challenge. This session's six presentations focused on advanced data analysis and dissemination efforts. They included audio detection and classification techniques, automated and semi-automated pattern recognition, as well as video discovery and annotation tools.

Bathy Mapping with UAS and Motion Software
Tim Battista, NOAA National Ocean Service (NOS)
Submitted via NOAA Call for Abstracts

This project uses imagery acquired from unmanned aircraft systems (UAS) which is processed using Structure from Motion (SfM) photogrammetry software. This software is used to generate a 2D mosaic of the seafloor and a 3D bathymetric model in near-coastal environments. This technology can help NOAA address unmet requirements for high-resolution bathymetric datasets in nearshore coastal zones, particularly in remote locations.

DAY TWO - THE BLUE ECONOMY

SESSION SEVEN
DATA ANALYTICS, PART TWO

DAY TWO, SESSION SEVEN
PRESENTATION SUMMARIES

Passive Acoustic Monitoring (PAM) Zoo
Shannon Rankin, NOAA National Marine Fisheries Service (NMFS)
Submitted via NOAA Call for Abstracts

The Passive Acoustic Monitoring (PAM) Zoo is a collaborative effort across NOAA Fisheries Science Centers to develop a standardized approach for passive acoustic monitoring of marine mammals. PAM Zoo is a flexible and modular approach to coordinated development of hardware, software, and analytical tools. It includes standard data collection software, a modular towed hydrophone array, a flexible machine learning approach to acoustic event classification, and Free Open-Source Software for Acoustics. Together, these components allow for standardized data collection, efficient and systematic data analysis, and production of comparable results. PAM Zoo can help reduce costs, while increasing capacity for marine mammal surveys to address a shared need at a national scale.

Large-Scale Deep Learning for Passive Acoustic Monitoring of Marine Mammals
Matt Harvey, Google LLC
Submitted via NOAA Call for Abstracts

Google and the Pacific Islands Fisheries Science Center have collaboratively developed a state-of-the-art machine learning framework and supporting infrastructure to detect and classify audio events at scale. The prototype implementation detects the presence of humpback whale vocalization in 75-second segments of audio data to help estimate species abundance. This system provides a high-performing option to supplement current NOAA methods used to detect and classify audio events in large acoustic datasets. The framework can also be integrated into existing NOAA workflows.

Enhancing Creation, Archival and Discovery of Video Annotations
Megan Cromwell and Susan Gottfried, NOAA National Environmental Satellite, Data, and Information Service (NESDIS)
Submitted via NOAA Call for Abstracts

The NOAA Office of Exploration Research (OER) SeaTubeV2 and Video Portal curate annotations of undersea videos from relevant experts, as well as search associated video. The OER Video Portal is a search tool that allows users to discover, preview, and retrieve videos from the archive holdings of National Centers for Environmental Information. SeaTubeV2 enables a geographically distributed team of subject matter experts (SMEs) to create annotations about the contents of a video as it is streamed over satellite-based internet in real time. Underwater videos and associated annotations are critical to establish an accurate baseline assessment of the ocean environment, which is essential for managing marine resources.

DAY TWO - THE BLUE ECONOMY

SESSION SEVEN
DATA ANALYTICS, PART TWO

DAY TWO, SESSION SEVEN
PRESENTATION SUMMARIES (cont'd)

InDX Platform
Daniah Tajudeen, Aalta, LLC
Submitted via RFI Process

The InDX Platform uses artificial intelligence techniques such as deep-learning methods to automate the identification of fish species, fish length, and fish weight from high-definition, *in situ* video footage. This technology can help NOAA use electronic monitoring systems for monitoring fisheries in a more effective, scalable, and deployable manner compared to traditional approaches.

Automated Processing of Underwater Imagery
William Michaels, NOAA National Marine Fisheries Service (NMFS)
Submitted via NOAA Call for Abstracts

This presentation highlighted two open source software products that use deep learning methods to automate processing of underwater imagery: Video and Image Analytics for a Marine Environment (VIAME) and CoralNet. VIAME automates the detection, classification, and measurement of fish. Meanwhile, CoralNet can automate the classification of benthic photoquadrats. These machine learning capabilities can also be used to conduct other observations, including automated detection and tracking of marine mammals. By automating time-consuming tasks, employing machine learning techniques has resulted in significant cost savings and improved data quality. Further applications will provide more timely and accurate information to NOAA fisheries managers and other decision-makers.

DR. FRANCISCO WERNER, PH.D., PANEL CHAIR
NOAA National Marine Fisheries Service (NMFS)
Director of Scientific Programs and Chief Science Advisor

DAY TWO: LEADERSHIP PANEL

The workshop concluded with a panel discussion, which focused on the challenges associated with transitioning from research to operations (R2O). The panel was developed and organized by the NOAA Research Council, one of the three 2019 ETW sponsors, to take advantage of emerging scientific and technological opportunities. The discussion centered on exploring why transitions sometimes stall and what can be done to prevent such barriers from occurring. The panel featured six NOAA leaders who highlighted and evaluated six themes around transitioning new and emerging technologies from research to operations, including:

01

Utilizing NOAA Administration Order (NAO) 216-105b on Transition
Gary Matlock, Ph.D.
NOAA Oceanic and Atmospheric Research (OAR)
Deputy Assistant Administrator for Science and Line Office Transition Managers Committee Chair

Gary Matlock kicked off the conversation by describing the development of the NOAA Administrative Order (NAO) 216-105b as a tool for improving the process of transitioning technology from research to operations. This NOAA policy establishes three components defining processes required for such transitions. These include: (1) Line Office Transition Managers who are identified as NOAA stakeholders that facilitate and ease the transition process; (2) Readiness Levels that describe the stage of a project within the transition process; and (3) a requirement to provide the proposed transition plan signed by both the research Line Office and the intended recipient as appropriate.

Matlock explained that there have been significant efforts to develop this policy from its origins to how it is defined today. He also mentioned that in addition to the improvements made to the NAO, NOAA has put forth other concurrent efforts, such as providing funds for competition to accelerate the R2O process. Matlock described the aim of these efforts as fostering early and sustained communication between the researchers and operators.

Matlock further emphasized that when thinking about transitions, it is important to remember that they do not move in a straight line. He went on to stress that science and knowledge can also be transitioned, not just technologies. Matlock concluded his presentation by expressing that research and development should be used to develop new innovations, in addition to improving existing operations.

DAY TWO: LEADERSHIP PANEL

02

Failed Transitions and Lessons Learned
William Michaels
NOAA National Marine Fisheries Service (NMFS)
Director, Ocean Technology Program, Office of Science & Technology

William Michaels focused his presentation on the importance of taking stock and learning from transitions that fail. In preparation for this panel, Michaels conducted a systematic review of past NMFS projects, including those that had succeeded and failed. He shared how his efforts helped illuminate components critical to success in the future, like optimizing partnerships and engaging end users from beginning to end, and providing seed money.

Another limitation, Michaels noted was the common misalignment between the private sector's process for developing technologies and NOAA's capacity to adopt these technologies into operations. Specifically, he emphasized that private sector developers often do not consider NOAA's operational mandates, and as a result build products that NOAA is unable to adopt and/or sustain. Michaels concluded by expressing the need for NOAA technologies to be reliable and sustainable over time in order to maintain the integrity of analyses and indices, and ultimately be the right fit for transition into operations.

03

Successful Transitions and Transition Jumpstarts
Harry Cikanek
NOAA National Environmental Satellite, Data, and Information Service (NESDIS)
Director, Center for Satellite Applications & Research (STAR)

Harry Cikanek began his presentation by explaining that the key behind smoothly transitioning new technologies into operations is putting in significant work at the early stages. Cikanek went on to credit the success of current NOAA projects, now operational, including the JPSS satellite and GOES-R satellite products, due to the greater effort put in at the beginning of each project's transition process. He added that it is important to take note of and harness NOAA's current programs dedicated to fostering transitions. Cikanek highlighted two examples, including the Joint Technology Transition Initiative's competitive grant program and the Earth Prediction Innovation Center, built to help facilitate R2O for models.

04

Use of Test Beds for Transitions
John Cortinas, Ph.D.
NOAA Oceanic and Atmospheric Research (OAR)
Director, Atlantic Oceanographic and Meteorological Laboratory (AOML)

John Cortinas described the value and relevance of NOAA's twelve "Test Bed Sites" built to facilitate the transition of research capabilities to operational use. Cortinas described these sites as physical facilities that provide NOAA stakeholders a space to test new techniques, tools, and technologies in an environment similar to actual conditions.

He went on to say that a key benefit of this approach is that operators can work alongside researchers to begin testing technologies at a readiness level 6-8. Cortinas concluded by highlighting that harnessing these testbeds has enabled the acceleration of research, which results in a much quicker turnaround time for technologies to be employed in an operational setting.

DAY TWO: LEADERSHIP PANEL

05 Cost-Benefit of Transitioning New Technologies

Steve Thur, Ph.D.
NOAA National Ocean Service (NOS)
Director, NOAA National Centers for Coastal Ocean Science (NCCOS)

Steve Thur focused his presentation on exploring effective transitions from the lens of cost, both monetary and non-monetary. Thur began by introducing three questions associated with the initial assessment process of adopting a new technology. The first two questions he described as those most often asked by scientists, including: "Can we do this?", and "How do we do this?" But, Thur said, what about the third and equally important question that scientists rarely ask: "Should we do this?"

He continued by explaining that while monetary costs of development and operations are generally considered, they are not often compared with a quantification of the benefits of the transitioned research to determine if the benefits outweigh the costs. In addition, the potential risk and benefit of a transition goes far beyond financial costs. Specifically, he emphasized that non-monetary costs associated with reputation, training or staffing, organizational culture, and relationship management can carry the same (if not higher) amount of risks but yet are rarely addressed in a transition plan.

He went on to identify the need to investigate societal benefits and consider them during cost-benefit analyses. Thur concluded that addressing these gaps can advance more effective decision-making and encouraged a more robust information gathering process when initiating transitions.

06 Solving the Operations and Management (O&M) Tail

Hendrik Tolman, Ph.D.
NOAA National Weather Service (NWS)
Senior Advisor, Advanced Modeling Systems, Office of Science and Technology Integration

Hendrik Tolman offered his take on opportunities to solve the Operations and Management (O&M) tail. Tolman began by clarifying the difference between the terms: "evolution" as doing something better; and "revolution" as doing something completely new. He went on to explain that solving the O&M tail for an evolving technology is relatively simple because the O&M budget already exists.

Alternatively, Tolman explained that when it comes to newer "revolutionary" technologies the burden is much greater. He continued by emphasizing that successful transitions for "revolutionary" or brand new technologies can only occur when an O&M budget can be put into place (i.e., the NOAA office leading the effort has a defined requirement for the capability/technology).

Tolman concluded by highlighting the importance of continued engagement by the NOAA office leading the transition effort and defining the new technology as a requirement for their operations. He noted that without the support and involvement of this stakeholder (i.e., the end user), projects may become stuck in the step just before transition, using up money to maintain the project, but ultimately, never fully accomplishing the transition into operations.

2019 WORKSHOP IN REVIEW : TAKEAWAYS AND FINDINGS

NOAA is working to accelerate the transition of cutting-edge science and technology research. NOAA continues to innovate by advancing capabilities for executing daily weather forecasts and severe storm warnings to protect lives and property. At the same time, NOAA is working to achieve strategic goals to advance the Blue Economy. 2019 ETW presentations highlighted several multi-use capabilities that advance both the Blue Economy and methods for detecting extreme weather and water events. For example, unmanned systems are becoming a growing tool enabling enhanced capabilities for a variety of ocean and coastal observations. In order to advance the processing of environmental observations data, NOAA is utilizing a variety of data analytics innovations. For example, NOAA is exploring the use of artificial intelligence and machine learning to enhance data synthesis.

Additional steps NOAA is taking include engaging in public-private partnerships, leveraging commercial cloud providers, and exploring advanced genomic techniques. Ultimately, all of these efforts to harness emerging technologies optimize NOAA's continued ability to provide critical information to the nation. NOAA is also working hard to address the challenges related to adopting and integrating new capabilities into its observing systems portfolio. The ETW is just one tool NOAA uses to achieve and sustain a portfolio that is mission-effective, integrated, adaptable, and affordable. In particular, there were several complementary activities highlighted during the 2019 ETW leadership panel regarding current NOAA activities and projects that can support this goal in conjunction with this workshop. The discussion included mentions about on-going activities across NOAA, such as:

ON-GOING NOAA ACTIVITIES ADVANCING R2O TRANSITIONS

- **NOAA is employing more efficient and expedient processes to foster innovation and promote new ideas (e.g., transitioning from writing computer models to using modeling frameworks).**
- **The NOAA Research Council actively strives to advance efficient processes for transitioning technologies into operations (e.g., modernizing the NAO 216-105b, using the NOAA Research and Development Database (NRDD), and offering funding to accelerate the R2O process).**
- **NOAA OAR is using the NRDD as a means to understand and track research and development projects, including how technologies presented at past ETWs are being used within NOAA.**
- **The National Centers for Coastal Ocean Science launched the Innovation Incentive Award to encourage scientists to attempt new initiatives without fearing failure. This award seeks and recognizes candidates who are dedicated to innovative endeavors, regardless of ultimate success.**
- **NOAA is sponsoring user engagement forums to collect input from community groups, NGOs, and other stakeholders. This input is used to identify previously unknown end users and develop more relevant products.**
- **NOAA has adopted best practices from other agencies (e.g., Readiness Levels) and the private sector (e.g., transition plans), while also focusing on prioritizing ways to strengthen internal processes through external engagement (e.g., public-private partnerships).**

2019 WORKSHOP IN REVIEW : SUCCESSES AND CHALLENGES

Since 2016, the ETW has continued to evolve, aiming to increase its relevance and value for the Earth observations community. In an effort to assess and optimize the planning and execution of the event from year to year, feedback is gathered from key stakeholders to inform recommendations and next steps.

For the 2019 ETW, two stakeholder groups were engaged to provide their feedback. These groups included (1) ETW registrants, attendees, session speakers, and poster presenters; and (2) NOAA personnel supporting ETW programming and logistics. Feedback from the first group was collected via an online survey, sent to all 2019 registrants, and yielding a 20% response rate. Feedback from the second group was collected via three discussion sessions, with 100% participation from all NOAA personnel involved in 2019 program planning and event logistics. Responses from both groups were analyzed and produced a number of key insights and overarching themes, including:

2019 ETW SUCCESSES

- **The knowledge base and subject matter expertise of 2019 ETW session speakers and poster presenters received high ratings from both survey respondents and discussion session participants.**
- **The overall satisfaction with the workshop structure and programming received high ratings from both survey respondents and discussion session participants.**
- **Participants expressed satisfaction with the diversity of presentations at the workshop as well as the value of the post-presentation panel discussion.**
- **New components launched for the 2019 ETW, including social media engagement and Science on a Sphere tours, received high ratings from survey respondents and discussion session participants.**

2019 ETW CHALLENGES

- **Survey respondents and discussion session participants expressed that limited opportunities for meaningful networking during the event was a major challenge.**
- **Survey respondents and discussion session participants identified lack of attendance and/or formal processes for engagement with NOAA leaders and/or decision-makers as a key limitation.**
- **Free registration results in a significant percentage of prospective attendees who initially register to attend the workshop, but later elect not to attend (no-shows).**
- **Many expressed that the venue's food options and service capacity were inadequate for the number of participants. The venue is equipped with limited conference amenities, limited parking, and a limited audio-visual infrastructure relative to the current size and complexity of the workshop.**

2019 WORKSHOP IN REVIEW : RECOMMENDATIONS AND NEXT STEPS

Over the next year, ETW organizers will use feedback on the workshop to develop and implement activities that build on the initial successes of the first three iterations of this workshop. More specifically, outreach targeting 2019 ETW session speakers, poster presenters, and all other attendees is planned for the remainder of 2019 and early 2020.

The purpose of these outreach efforts will be to foster meaningful networking and incentivize collaboration among 2019 ETW stakeholders, NOAA leaders, and decision-makers. Additional next steps are listed below. Further recommendations will be developed in consultation with NOAA's three strategy councils. Ultimately, these activities aim to advance opportunities for NOAA's adoption of the technologies, tools, and/or processes showcased during the 2019 ETW and during future iterations of this event.

2019 ETW NEXT STEPS

- **ETW planners will work with NOAA leadership, NOAA Line Offices, and project managers to pursue cost-effective technologies and techniques to fill NOAA's observing gaps.**
- **NRDD will be utilized to track current and future R&D involving technologies presented at the workshop.**
- **To make future workshops more successful, NOAA will more clearly define the purpose of the workshop and expected outcomes for both NOAA and external attendees.**
- **Future ETWs will be aligned with grant programs and requirements to more clearly articulate NOAA's observing needs and to prioritize gaps that have available funding.**
- **ETW planners will work with key NOAA personnel to continue to refine logistical aspects of the workshop based on workshop feedback and internal discussions.**
- **In order for the scope of this event to grow and evolve beyond the size and complexity of this past iteration, additional funding will be required.**
- **Funding and development opportunities such as the Small Business Innovative Research (SBIR) program, Cooperative Research And Development Agreements (CRADA), and the Technology Partnership Office (TPO) will be leveraged to ensure more successful outcomes.**

REPORT APPENDIX A : 2019 WORKSHOP AGENDA

2019 NOAA Emerging Technologies Workshop
NOAA Center for Weather and Climate Prediction (NCWCP)
College Park, Maryland
June 25-26, 2019

Day 1 – June 25 Resilience to Extreme Weather and Water

08:30 - 08:45
Welcome and Opening Remarks
Observing Systems Committee (OSC) Co-Chairs, Richard Edwing and Tom Cuff
Agenda overview, ground rules, and logistics

08:45 - 09:00 Keynote Address:
RDML Tim Gallaudet, Ph.D., USN Ret.

09:00 - 10:10 Session 1: Hydrometeorological Extremes

09:00 - 09:05
Introduction
Neal DiPasquale, NOAA NWS

09:05 - 09:15
MoPED - Mobile Platform Data Generation for Flash Flooding and Extreme Weather
Paul Heppner, Global Science and Technology

09:15 - 09:25
Automated NonContact Hydrologic Observations in Rivers
Daniel Wasielewski, NOAA OAR/NSSL

09:25 - 09:35
FFIoT – Flash Flood Internet-of-Things
Chris Ulmer (sub for Ian Helmuth), Intellisense Systems Inc.

09:35 - 09:45
Decision Support at Regional Scales: Connecting Emerging Technologies to User Needs in a NOAA Services Framework
Ellen Mecray, NOAA NESDIS/NCEI

09:45 - 10:10 Panel Q&A

10:10 - 10:40 Break & Posters

REPORT APPENDIX A : 2019 WORKSHOP AGENDA

Day 1 – June 25 Resilience to Extreme Weather and Water

10:40 - 12:00 Session 2: Remote Sensing for Extreme Atmospheric Events

10:40 - 10:45
Introduction
John Cortinas, Ph.D., NOAA OAR/WAQ

10:45 - 10:55
Wide Swath Radar Altimeter
Edward Walsh (sub for Chris Fairall), NOAA OAR/ESRL

10:55 - 11:05
Airborne Phased Array Radar
Vanda Grubišić, UCAR

11:05 - 11:15
Stratospheric Observations of Earth Systems (SOES)
Kenneth Howard, NOAA OAR/NSSL

11:15 - 11:25
Airborne Doppler Wind Lidar Sounder
George Emmitt, Simpson Weather Associates

11:25 - 11:35
Airborne Radar Network (AiRNet) project
Jonathan Gourley, NOAA OAR/NSSL

11:35 - 12:00
Panel Q&A

12:00 - 13:30 Lunch & Posters & Science on a Sphere tours

13:30 - 15:00 Session 3: Artificial Intelligence

13:30 - 13:35
Introduction
Sidney Thurston, Ph.D., NOAA OAR/CPO/OOMD

13:35 - 13:45
Amazon Web Services
Joseph Flasher, Amazon

REPORT APPENDIX A : 2019 WORKSHOP AGENDA

Day 1 – June 25 Resilience to Extreme Weather and Water

13:30 - 15:00 Session 3: Artificial Intelligence (cont'd)

13:45 - 13:55
Google Cloud's Efforts to Enhance Data Discoverability and Access
Shane Glass, Google LLC

13:55 - 14:05
Machine Learning for Earth Observation and Environmental Prediction (EOEP)
Jebb Stewart (sub for Sid Boukabara)
NOAA NESDIS/STAR

14:05 - 14:15
The Weather Archive and Visualization Environment (WAVE)
Jebb Stewart (sub for Dan Nietfeld), NOAA OAR/ESRL

14:15 - 14:25
A Data Driven Approach for Modeling Ocean Temperature and Salinity Using Observational and Computational Data
Luca Bonfiglio, MIT

14:25 - 14:35
Deep learning approach for detecting precursors of tropical cyclone - Toward Cyclogenesis Prediction
Daisuke Matsuoka, JAMSTEC

14:35 - 15:00 Panel Q&A

15:00 - 15:30 Break & Posters

15:30 - 16:50 Session 4: Data Analytics (Part 1)

15:30 - 15:35
Introduction
Kim Valentine, NOAA NOS/IMO

15:35 - 15:45
Geospatial Image Services for NOAA's Geostationary Weather Satellite Constellation
Rafael de Ameller, NOAA NESDIS/CS

REPORT APPENDIX A : 2019 WORKSHOP AGENDA

Day 1 – June 25 Resilience to Extreme Weather and Water

15:30 - 16:50 Session 4: Data Analytics (Part 1) (cont'd)

15:45 - 15:55
Real-time Event Identification in Social Sources (REISS)
John Chauvin, Intellisense Systems Inc.

15:55 - 16:05
Live Access Server data visualization and analysis platform (LAS)
Eugene Burger, NOAA OAR/PMEL

16:05 - 16:15
Hyperspectral Imager for Updated Littoral Situational Awareness (HULA)
Charles Bachmann & Reid Nichols, RIT/Chester F. Carlson Center for Imaging Science

16:15 - 16:25
NESDIS Financial Management Data System (FMDS)
Michael Weiland, NOAA NESDIS/OSFO

16:25 - 16:50 Panel Q&A

16:50 - 17:00
Closing Remarks and Overview of Day Two
Richard Edwing & Tom Cuff

Day 2 – June 26 The Blue Economy

08:20 - 08:30
Opening Remarks by OSC Co-Chairs, Richard Edwing and Tom Cuff
Day One recap, Day Two overview, ground rules, and logistics

08:30 - 08:45
Keynote Address: Cisco Werner, Ph.D

08:45 - 10:05 Session 5: Resource Mapping

08:45 - 08:50
Introduction
Frank Schwing, Ph.D., NOAA NMFS/OST/SID

REPORT APPENDIX A : 2019 WORKSHOP AGENDA

Day 2 – June 26 The Blue Economy

08:45 - 10:05 Session 5: Resource Mapping (cont'd)

08:50 - 09:00
Underwater Spherical Camera System
Ryan Caillouet, NOAA NMFS/SEFSC

09:00 - 09:10
Fish-i
Erik C. Franklin & Prospero Naval, University of Hawai'i/Hawai'i Institute of Marine Biology & University of the Philippines

09:10 - 09:20
SAILDRONE: A Global USV Network for In-Situ Ocean Observations
Nora Cohen (sub for Sebastien de Halleux), SAILDRONE Inc

09:20 - 09:30
VMS augmented with satellite and terrestrial AIS and the newly available Hawkeye360 data
Steve Lewis, NOAA NMFS/Alaska Region

09:30 - 09:40
Vemco Live Aquatic EcoSystem Observer
Jeremy Kuehner & Aaron Legge, InnovaSea Systems

09:40 - 10:05 Panel Q&A

10:05 -10:35 Break & Posters

10:35 - 11:55 Session 6: Coastal Risk

10:35 - 10:40
Introduction
Jonathan Pennock, Ph.D., NOAA OAR/NSGCP

10:40 -10:50
Containerized Autonomous Marine Environmental Laboratory (CAMEL)
Andrew Ziegweid, ASV Global

REPORT APPENDIX A : 2019 WORKSHOP AGENDA

Day 2 – June 26 The Blue Economy

10:35 - 11:55 Session 6: Coastal Risk (cont'd)

10:50 - 11:00
Advanced Coastal Monitor: Autonomy and Modularity in Marine Survey Vehicles
William Latham, Tridentis AMV

11:00 - 11:10
Mobile, In-situ HAB Toxin Warning and Genomic Observation for the Great Lakes
Greg Doucette (sub for Steve Ruberg), NOAA NOS/NCCOS

11:10 - 11:20
HABscope: A Tool For Use By Citizen Scientists To Facilitate Near Real-Time Warning of Respiratory Irritation Caused By Toxic Blooms of *Karenia brevis*
Chris Holland, NOAA NOS/NCCOS

11:20 - 11:30
Smartcoastlines.org - realization of scalable, low-cost, versatile, environmental Internet of Things for the coastal zone
Brian T. Glazer, University of Hawai'i at Manoa

11:30 - 11:55 Panel Q&A

11:55 - 13:30
Lunch & Posters & Science on a Sphere tours

13:30 - 15:00 Session 7: Data Analytics (Part 2)

13:30 - 13:35
Introduction
John McDonough, NOAA OMAO

13:35 - 13:45
Passive Acoustic Monitoring (PAM) Zoo
Shannon Rankin, NOAA NMFS/SWFSC

13:45 - 13:55
Large-Scale Deep Learning for Passive Acoustic Monitoring of Marine Mammals
Matt Harvey (sub for Aren Jansen), Google LLC

REPORT APPENDIX A : 2019 WORKSHOP AGENDA

Day 2 – June 26 The Blue Economy

13:30 - 15:00 Session 7: Data Analytics (Part 2) (cont'd)

13:55 - 14:05
Bathy Mapping with UAS and Motion Software
Tim Battista, NOAA NOS/NCCOS

14:05 - 14:15
InDX Platform
Daniah Tajudeen, Aalta LLC

14:15 - 14:25
Enhancing creation, archival and discovery of video annotations
Megan Cromwell & Susan Gottfried (sub for Mashkoor Malik), NOAA NESDIS/NCEI

14:25 - 14:35
Automated processing of underwater imagery
Bill Michaels (sub for Ben Richards), NOAA NMFS

14:35 - 15:00 Panel Q&A

15:00 - 15:30 Break & Posters

15:30 - 16:30
No Transitions, No Outcomes Panel Discussion (NOAA Research Council)

Panel members:
Francisco Werner, Ph.D., Chair
Steve Thur, Ph.D., NOS
Hendrik Tolman, Ph.D., NWS
John Cortinas, Ph.D., OAR
William Michaels, NMFS
Harry Cikanek, NESDIS
Gary Matlock, Ph.D., OAR

16:30 Closing Remarks

REPORT APPENDIX B : 2019 POSTER LIST

TECHNICAL POSTERS FOR THE EXTREME WEATHER AND WATER THEME

Data Assimilation of TEMPEST Brightness Temperatures
Steve Reising, Colorado State University

A novel low-cost, high-precision sea temperature sensor for coral reef monitoring
Natchanon Amornthammarong, NOAA/OAR/AOML

Rapid Airborne Multibeam Mapping System: A New Sensor to Support Coastal Resilience
David Millar for Todd Mitchell, Fugro

An ESPA-Class Small-Sat Conical Microwave Imager
Shannon Brown, NASA/JPL

Multipurpose Above Surface/Below Surface Expendable Dropsonde
Andrew Keefe, Boston Engineering Corporation

GROOV - GARC Rapid Ocean Observing Vessel
Elizabeth Hines, Doug Wilson, Maritime Applied Physics Corporation

Coastal Storm Micro Observer (COSMO)
Chris Ulmer, Intellisense Systems Inc. (ISI)

Measurement and Monitoring of Ocean Tides Using GPS reflectometry
Bill Adams, Atmospheric & Space Technology Research Associates (ASTRA), LLC

ASTRALiTe Topo-Bathy LiDAR
Bill Adams, Atmospheric & Space Technology Research Associates (ASTRA), LLC

Atmospheric Monitoring, Forecasting & Analytics Using GNSS RO
Chris McCormick, PlanetIQ

Absolute Radiance Interferometer (ARI)
Henry Revercomb, Univ of Wisconsin-Madison (UW) - Space Science & Engineering Center (SSEC)

Lower Tropospheric Observing System (LOTOS)
Terry Hock for Vanda Grubišić, UCAR/EOL

Cloud-G Platform and Fourier Scattering Transform
Tejbir Phool, MiMoCloud

REPORT APPENDIX B : 2019 POSTER LIST

TECHNICAL POSTERS FOR THE BLUE ECONOMY THEME

Transformation of the Argos Data Collection System in the 2020s
Scott Rogerson, NOAA/NESDIS/OSPO

Applications from autonomous vehicles in partnership with Tridentis AMV
Robert A. Warner, NOAA/NOS/NCCOS

Pacific Northwest Harmful Algal Bloom Bulletin
Tiffany C. Vance, NOAA/NOS/IOOS

Saildrone
Chris Meinig, NOAA/OAR/PMEL

Improving Performance of Acoustic Current Profiler Sensors on Small, Dynamic Surface Buoy
Robert Heitsenrether, NOAA/NOS/CO-OPS/SVC

Simplified Water Level Measurement Systems for NWLON Gaps
Robert Heitsenrether, NOAA/NOS/CO-OPS/SVC

Underwater Winch for Polar Region Studies
Haru Matsumoto, NOAA/OAR/PMEL

Shipboard Launch and Recovery of UAS
Kenneth Vierra for Patricia Quinn, NOAA/OAR/PMEL

Measurements from sUAS using the MiniFlux Sensor Package
Janet Intrieri, NOAA/OAR/ESRL/PSD

Image Recognition of Buoy Camera Images at NDBC
Joseph A. Stewart, NOAA/NWS/NDBC

Matching NOAA's Policy Priorities to Opps for Investment
Joseph Conran, NOAA/NESDIS/TPIO

mPing
Kimberly Elmore, NOAA/OAR/NSSL

Machine Learning Methods for Acoustic Events
Ann Allen, Erin Oleson, Carrie Wall Bell, NOAA/NESDIS/NCEI/Fisheries Archive

REPORT APPENDIX B : 2019 POSTER LIST

TECHNICAL POSTERS FOR THE BLUE ECONOMY THEME

SAILDRONE: A Global USV Network for In-Situ Ocean Observations
Nora Cohen, SAILDRONE, Inc.

Satellite Derived Bathymetry (SDB) based on Ocean Optics
Jeffrey Clauson for Minsu Kim, USGS Earth Resources Observation and Science (EROS) Center

Emerging Technology Applied to Great Lakes and Watershed Monitoring
John Bratton, LimnoTech

GeoCollaborate
Dave Jones, Storm Center Communications, Inc.

Land Cover Mapping API
Laura Dobbs, Microsoft Corporation

REPORT APPENDIX C : 2019 ETW ACKNOWLEDGEMENTS

Since its inception in 2016, the NOAA ETW has been a coordinated effort made possible through the collaboration, hard work, and support of numerous groups across the agency. This year's workshop was no exception with representatives from NOAA leadership and all six Line Offices taking on roles from program planning through execution, each integral to the event's success. We would like to express our sincere gratitude to all those who assisted in making it possible.

NOAA Strategy Council Hosts

NOAA Observing Systems Council
NOAA Research Council
NOAA Ocean and Coastal Council

Workshop Co-Chairs/Program Planning Chairs

Rich Edwing, *NOAA Observing Systems Committee Co-Chair*
Tom Cuff, *NOAA Observing Systems Committee Co-Chair*

Keynote Speakers

RDML Tim Gallaudet, Ph.D., USN Ret.
Dr. Francisco Werner, Ph.D.

Session Chairs (Program Development)

Neal DiPasquale, *Hydrometeorological Extremes*
John Cortinas, *Remote Sensing for Extreme Atmospheric Events*
Sidney Thurston, *Artificial Intelligence*
Kim Valentine, *Data Analytics for Severe Weather*
Frank Schwing, *Resource Mapping*
Jonathan Pennock, *Coastal Risk*
John McDonough, *Data Analytics*
Francisco Werner, *Emerging Technologies Panel Discussion Chair*

Program Planning Team

Meredith Wagner, *ETW Program Planning Lead Coordinator*
Anne Kennerley, *Program Planning Support, Logistical Planning Liaison*
Jennifer Webster, *Asst Program Team Coordinator*
Martin Yapur, *NOAA Technology, Planning and Integration for Observation (TPIO) Division Chief*
Eric Miller, *TPIO Deputy Division Chief*

REPORT APPENDIX C : 2019 ETW ACKNOWLEDGEMENTS

Logistical Planning Team Leads

Adam Steckel, *ETW Lead Logistician, RFI Coordinator*
Daniel Gillespie, *Logistician, Dashboard Webmaster, Photography*
Bianca Terry, *Technical Poster Gallery Curator*

Logistical Planning Team Members

Kennita Diggs, *Administrative & Purchasing Support*
Mary Beth Wilson, *Attendee Relations Support*
Christopher Pagán, *Attendee Relations Support*
Anastasia Sonneman, *Marketing Support, Report Developer & Editor*
Saiontoni Sarkar, *Report Developer & Editor*
Sabra Comet, *Report Developer*
Katerina Merezhinsky, *Graphic Design*
Mark Middlebusher, *Marketing Support, Speaker Support*
Edward Borders, *Speaker Support*
Thanh Vo Dinh, *Session Rapporteur*
Justin Goldstein, *Session Rapporteur*
Matt Austin, *Session Rapporteur*

TPIO Requirement Gaps Methodology Analysts

David Helms, *TPIO Analysis Team Lead, RFI Developer*
Sabrina Taijeron, *TPIO Analysis Team Lead*
Joe Conran, *Lead Requirement Gaps Methodology Analyst*
Aaron Pratt, *Contributing TPIO Analyst*
Brant Priest, *Contributing TPIO Analyst*

Special Thanks to:

David Marks, *AGO RFI Reviewer*
Jason Taylor, *NCWCP Venue Sponsor (2019)*
William Lapenta, *NCWCP Venue Sponsor (2017)*
Clifton Capes, *NCWCP Venue Support*
Seok Kwon, *NCWCP Venue Support*
Renata Lana, *NESDIS Communications, Marketing Support*
Alix Hines, *NESDIS Communications, Marketing Support*

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